U.S. Department
of Transportation
**National Highway
Traffic Safety
Administration**

1200 New Jersey Avenue SE.
Washington, DC 20590

July 27, 2021

ACTION MEMORANDUM TO THE SECRETARY

From:	Steven S. Cliff, Ph.D. Acting Administrator (202) 819-2482
Prepared by:	Joseph Kolly Acting Associate Administrator Enforcement x6-5756
Through:	Maria Lefevre Executive Director Office of the Under Secretary of Transportation for Policy x6-4540
Subject:	Report to Congress on Vehicle Safety Recall Completion Rates

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ACTION REQUIRED

I request that you approve the attached National Highway Traffic Safety Administration's (NHTSA) Report to Congress on Vehicle Safety Recall Completion Rates.

SUMMARY

This report, the final of three required reports, responds to the Fixing America's Surface Transportation (FAST) Act requirement that the Secretary of Transportation conduct an analysis of vehicle safety recall completion rates and submit the findings of that report to the Committee on Commerce, Science, and Transportation of the Senate and the Committee of Energy and Commerce of the House of Representatives.

This report, as with the previous two reports, analyzes the following:

- The annual recall completion rate by manufacturer, model year, component (such as brakes, fuel systems, and air bags), and vehicle type (passenger car, sport utility vehicle, passenger van, and pick-up truck) for each of the 5 years before the year the report is

submitted; and
- The methods by which the Secretary has conducted analyses of these recall completion rates to determine trends and identify risk factors associated with lower recall rates.

Among all vehicles recalled by major light vehicle manufacturers between 2014 and 2018, 60 percent were remedied by the fifth quarter of the recall. Though average completion rates have improved from the previous two reports, NHTSA continues to strive for improvements in the safety recall process and ensuring as many owners as possible seek remedies for recalled vehicles. NHTSA hopes to utilize the statistical analysis in this report to continue development and utilization of predictive modeling, continued facilitation of sharing of information, and improved communications outreach to consumers and manufacturers.

Please note that the attached report is an update of the data and analysis of the previous two reports and utilizes the same format and structure. The previous two reports can be found here:

- https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/13376-recall_completion_rates_rtc-tag_final.pdf
- https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/18-3122_vehicle_safety_recall_completion_rates_report_to_congress-tag.pdf

Currently, the authority to send reports to Congress is reserved for the Secretary pursuant to Section 24104 of the FAST Act.

DUE DATE AND STATEMENT OF LATENESS

This report was due to Congress on December 4, 2020. The report was late due to agency review and change of Administration.

RECOMMENDATION

I recommend that you sign the transmittal letters and approve the report.

The Secretary

APPROVED: _____

DATE: 8/6/21

COMMENTS:

Attachments:
- Transmittal Letters
- Report to Congress

THE SECRETARY OF TRANSPORTATION
WASHINGTON, DC 20590

August 6, 2021

The Honorable Maria Cantwell
Chair
Committee on Commerce, Science, and Transportation
United States Senate
Washington, DC 20510

Dear Chair Cantwell:

Enclosed is the third of three biennial reports regarding motor vehicle safety recall completion rates in accordance with Section 24104 of the Fixing America's Surface Transportation (FAST) Act, Pub. L. 114-94.

Section 24104 of the FAST Act requires the Secretary of Transportation to "conduct an analysis of vehicle safety recall completion rates to assess potential actions by the National Highway Traffic Safety Administration to improve vehicle safety recall completion rates" and submit three biennial reports on the findings.

This report, as with the previous two reports, analyzes:

- the annual recall completion rate by manufacturer, model year, component (such as brakes, fuel systems, and air bags), and vehicle type (passenger car, sport utility vehicle, passenger van, and pick-up truck) for each of the 5 years before the year the report is submitted;
- the methods by which the Secretary has conducted analyses of these recall completion rates to determine trends and identify risk factors associated with lower recall rates; and
- the actions the Secretary has planned to improve recall completion rates based on the results of this data analysis.

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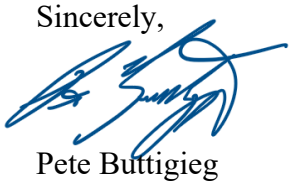
A similar letter was sent to the Ranking Member of the Senate Committee on Commerce, Science, and Transportation and to the Chair and Ranking Member of the House Committee on Energy and Commerce.

Sincerely,



Pete Buttigieg

Enclosure

THE SECRETARY OF TRANSPORTATION
WASHINGTON, DC 20590

August 6, 2021

The Honorable Roger Wicker
Ranking Member
Committee on Commerce, Science, and Transportation
United States Senate
Washington, DC 20510

Dear Ranking Member Wicker:

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Section 24104 of the FAST Act requires the Secretary of Transportation to "conduct an analysis of vehicle safety recall completion rates to assess potential actions by the National Highway Traffic Safety Administration to improve vehicle safety recall completion rates" and submit three biennial reports on the findings.

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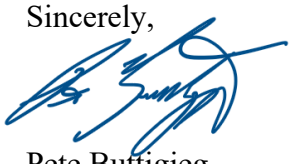

Pete Buttigieg

Enclosure

THE SECRETARY OF TRANSPORTATION
WASHINGTON, DC 20590

August 6, 2021

The Honorable Frank Pallone, Jr.
Chairman
Committee on Energy and Commerce
U.S. House of Representatives
Washington, DC 20515

Dear Chairman Pallone:

Enclosed is the third of three biennial reports regarding motor vehicle safety recall completion rates in accordance with Section 24104 of the Fixing America's Surface Transportation (FAST) Act, Pub. L. 114-94.

Section 24104 of the FAST Act requires the Secretary of Transportation to "conduct an analysis of vehicle safety recall completion rates to assess potential actions by the National Highway Traffic Safety Administration to improve vehicle safety recall completion rates" and submit three biennial reports on the findings.

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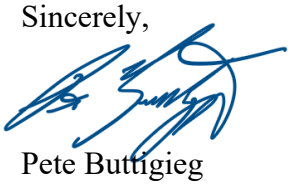

Pete Buttigieg

Enclosure

THE SECRETARY OF TRANSPORTATION
WASHINGTON, DC 20590

August 6, 2021

The Honorable Kathy McMorris Rogers
Ranking Member
Committee on Energy and Commerce
U.S. House of Representatives
Washington, DC 20515

Dear Ranking Member McMorris Rogers:

Enclosed is the third of three biennial reports regarding motor vehicle safety recall completion rates in accordance with Section 24104 of the Fixing America's Surface Transportation (FAST) Act, Pub. L. 114-94.

Section 24104 of the FAST Act requires the Secretary of Transportation to "conduct an analysis of vehicle safety recall completion rates to assess potential actions by the National Highway Traffic Safety Administration to improve vehicle safety recall completion rates" and submit three biennial reports on the findings.

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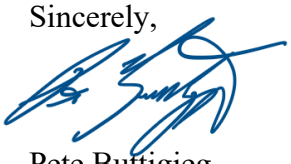

Pete Buttigieg

Enclosure

Report to Congress:

"Vehicle Safety Recall Completion Rates Report"

Prepared by the

U.S. Department of Transportation

National Highway Traffic Safety Administration

August 2021 Biennial Report (#3 of 3)

This report is submitted in response to the request by Congress under the Fixing America's Surface Transportation Act (FAST Act). The FAST Act authorizes funds for Federal-aid highways, highway-safety programs, transit programs, and other purposes.

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I. INTRODUCTION

On December 4, 2015, President Obama signed into law the Fixing America's Surface Transportation Act (FAST Act). This law provides long-term funding for Federal-aid highways, highway-safety programs, transit programs, and other purposes.

Section 24104 of the FAST Act, "Recall Process" states that:

(c) RECALL COMPLETION RATES REPORT. — (1) IN GENERAL.—Not later than 1 year after the date of enactment of this Act, and biennially thereafter for 4 years, the Secretary shall—

(A) conduct an analysis of vehicle safety recall completion rates to assess potential actions by the National Highway Traffic Safety Administration to improve vehicle safety recall completion rates; and

(B) submit to the Committee on Commerce, Science, and Transportation of the Senate and the Committee on Energy and Commerce of the House of Representatives a report on the results of the analysis.

(2) CONTENTS.—Each report shall include—

(A) the annual recall completion rate by manufacturer, model year, component (such as brakes, fuel systems, and air bags), and vehicle type (passenger car, sport utility vehicle, passenger van, and pick-up truck) for each of the 5 years before the year the report is submitted;

(B) the methods by which the Secretary has conducted analyses of these recall completion rates to determine trends and identify risk factors associated with lower recall rates; and

(C) the actions the Secretary has planned to improve recall completion rates based on the results of this data analysis.

This report, the final of three required reports, responds to the FAST Act requirement that the Secretary of Transportation conduct an analysis of vehicle safety recall completion rates and submit the findings of that report to the Committee on Commerce, Science, and Transportation of the Senate and the Committee of Energy and Commerce of the House of Representatives.

II. BACKGROUND

The National Highway Traffic Safety Administration ("NHTSA" or "the Agency") works each day to administer safety recalls in accordance with the National Traffic and Motor Vehicle Safety Act ("the Safety Act"). *See* 49 U.S.C. Chapter 301. Safety recalls are conducted when manufacturers of motor vehicles or motor vehicle equipment determine that a safety defect is present in the manufacturer's product or that the product does not conform to an applicable federal motor vehicle safety standard.[1] When a manufacturer issues a safety recall, 49 CFR Parts 573 and 577 require, among other things, the manufacturer to complete the following:

i. Notify the Agency with a Part 573 Recall Report which identifies the recalled product, summarizes the safety problem, and details the manufacturer's plans to offer a free remedy.

ii. Notify owners and purchasers, by First Class mail, of the recall and the available free remedy to address the safety risk.

iii. Report to the Agency for six quarters the number of recalled products that have been remedied by the manufacturer.

[1] 49 U.S.C. § 30118 also authorizes the Secretary of Transportation to decide when a motor vehicle or motor vehicle equipment contains a safety defect or a noncompliance with a federal motor vehicle safety standard.

The quarterly reports include counts for how many vehicles were remedied; how many were inspected but no remedy was required; and how many were exported, stolen, scrapped, or the owner could not be reached (e.g., undeliverable mail).

III. METHODOLOGY, DATA CONSTRAINTS, AND OTHER CONSIDERATIONS

NHTSA's methodology for examining recall quarterly reports is as follows:

a. Scope of this Report

The FAST Act specifies light vehicle applications to be studied. NHTSA categorizes light vehicles into three major categories: Light Trucks, Multipurpose Passenger Vehicles ("MPV") such as sport utility vehicles ("SUV") and minivans, and Passenger Cars. For each category, the Agency examined the number of vehicles that were reported as being remedied. Excluded from this report are recalls which include a combination of both light and heavy-duty vehicles, as it is not possible to separate the light vehicle remedy rates from the heavy-duty remedy rates.[2]

Many safety recalls involve more than one type of light vehicle. For example, Honda recall 18V-041 (Subject: Passenger Frontal Air Bag Inflator May Explode) includes the Acura RL (passenger car), Honda Element (MPV), and Honda Ridgeline (light truck), among other models. Of the 1,526 recalls analyzed in this report received between 2014 and 2018, 292 recalls (19%) involved a combination of passenger cars, MPVs, and light trucks. As such, the Agency created

[2] Sections III.c.4-5 provide additional details about this data limitation.

an additional category labeled “Mix” for this report to indicate recalls that include a combination of vehicle types.

For this report, the Agency examined recalls issued between 2014 and 2018 in which the manufacturer reported the recall’s completion status for at least five quarters after the remedy program became available (as of June 1, 2020). Only the fifth reporting quarter rate was analyzed even if more recent quarterly reports were available; however, if the recall reached 100% completion prior to the fifth quarter, then that quarterly report was utilized in the calculations. This refinement serves to control for variability in the length of reporting periods among manufacturers, as some companies continue to submit well after the minimum regulatory requirement. Recalls that had not reached this fifth-quarter maturation point—including recalls filed in calendar years (CY) 2019 and 2020—were not included because these recalls could similarly misrepresent the completion picture.

b. Calculating Recall Completion Rates

The Agency uses a standard formula for measuring a recall completion rate. This formula is the number of vehicles reported as remedied (including vehicles reported as inspected but not requiring remedy and vehicles returned to inventory) divided by the total number of vehicles involved in the recall (less any vehicles reported as being exported, stolen, scrapped, or unavailable for other legitimate reasons). NHTSA’s completion rate formula is:

Recall Completion Rate =

$$\left(\frac{\text{Count of Vehicles Remedied}}{\text{Count of Vehicles in Recall} - \text{Vehicles Exported, Stolen, Scrapped, Other}} \right) * 100$$

This report will reference the annual completion rate. This rate is a volume-based, weighted metric, such that the more vehicles affected by the recall, the more weight or influence it has on the computed rate. An alternative metric is the average, unweighted completion rate, in which each of a manufacturer's recalls carry the same influence or weight relative to other recalls. As the population size for light vehicle recalls can vary widely, unweighted averages are not used in this report to present a more accurate picture of remedy completion rates.

c. Limitations of the Data

This report compares recall completion rates among multiple variables, including the manufacturers and vehicle components involved. However, the Agency notes that the findings provide only a partial picture. The Agency understands myriad factors affect recall completion rates and many of these factors are intangible, difficult (if not impossible) to measure quantitatively, and/or not available to NHTSA. Accordingly, this report provides metrics and analysis based on data that NHTSA receives and maintains, but the following caveats should be noted:

1. No demographic information: Owner demographics, including socioeconomic factors and location of residence, as well as each owner's subjective assessment of risk, are believed to play a significant role in recall completion. However, this data is not systematically collected by the Agency.

2. Limited verification of manufacturer-supplied figures: The Agency is unable to verify the number of remedied vehicles reported by manufacturers with the limited data available to it. It should be noted that manufacturers are not required to provide that level of granularity to their

completion reports. Likewise, the Agency cannot independently verify the number of vehicles reported by manufacturers as exported, stolen, scrapped, or otherwise legitimately deducted from the number of vehicles recalled.

3. Initial parts shortages and restrictions: Delays in the design, manufacturing, or supply of remedy parts can affect the availability of a recall remedy, particularly when a manufacturer first launches a remedy program. Such delays and parts shortages could thus be a factor in recall completion, especially if vehicle owners become frustrated or apathetic after attempting to obtain a remedy that is not yet available. When the Takata air bag recalls began, for example, several recalls were delayed or used a phased launch due to a lack of available parts. However, given the limited data available, the Agency is unable to reliably measure the connection or the magnitude of any impact such a delay may have on recall completion rates.

4. No detailed model year breakdown: As discussed later in this report (see Section IV.b), recall completion rates appear to be significantly impacted by the age of the vehicles involved. However, NHTSA only receives data for the <u>total number</u> of vehicles affected and repaired for a given recall without any breakdown for vehicle age. A recall impacting 100,000 model year 2014 and 2015 vehicles might include 99,000 model year 2014 vehicles and 1,000 model year 2015 vehicles, or vice versa. Without that breakdown, NHTSA is unable to determine how many vehicles of each model year had been remedied, and thus is limited in its ability to measure the precise effect that vehicle age has on recall completion rates.

5. No detailed model breakdown: A safety recall can include a variety of models. However, as with model years, manufacturers are not required to report their recall populations providing this level of granularity. For example, a Ford recall for 1 million vehicles might include the Ford

Explorer and the Ford Mustang. However, the specific number of affected Explorers versus Mustangs would not be provided to NHTSA. Similarly, when the manufacturer submits its quarterly completion reports, it would not be clear how many Explorers were remedied versus the number of Mustangs remedied.

6. No measure of severity: NHTSA does not categorize recalls according to the degree of risk they pose. Although all recalls address safety risks, vehicle owners might be less motivated to seek a remedy for a matter they perceive to be "low-risk." In this analysis, NHTSA attempts to control for severity by examining recalls with descriptions which mention a vehicle crash or fire. But this control is imperfect. These terms may not necessarily be used in only the most high-risk recalls, or they may be used when describing recalls that vehicle owners may not perceive to be particularly high-risk. For example, the word "crash" might be included in the recall description for an incorrect tire pressure label because overinflated tires could explode and cause a crash. Nonetheless, some owners might not perceive the risk of an incorrect label as severe enough to warrant obtaining the remedy.

7. No measure of cost: A vehicle owner may be more likely to take advantage of a free repair for an issue he or she perceives would be costly under normal repair circumstances. However, the Agency does not have data indicating how much each recall remedy costs (or is perceived by owners to cost).

8. Inconsistent component classification: This analysis uses a component classification that is determined by NHTSA's analysis of the Part 573 Recall Reports it receives. While NHTSA strives to be consistent in its classification choices, a degree of subjectivity is required when aligning manufacturers' coding with the Agency's classification scheme, given the variety of

components that can necessitate a recall. Also, inconsistencies across manufacturers can present challenges to utilizing a uniform taxonomy for vehicle components.

9. Limited time period: The analysis in this report is based on recalls that were issued between 2014 and 2018. To the extent that the recalls undertaken during this time period were not representative or materially different in other time periods, a randomized analysis of these recalls is not applicable.

d. What Can and Cannot be Concluded from this Analysis

The analysis found in this report is presented in two parts. Sections IV and V.b present "raw data" on which no statistical modeling has been performed. Sections V.c through V.e present results from a statistical model.

Using the raw data, the Agency can draw some tentative conclusions, but these should be viewed cautiously. For example, Figure 1 (see Section IV.a) indicates that some manufacturers tend to have higher recall completion rates. However, this may be misleading because manufacturers issued different types of recalls between 2014 and 2018. Some manufacturers had more air bag recalls, while some had more seat belt recalls. Some manufacturers had multiple recalls involving older vehicles, while some manufacturers had recalls for newer vehicles.

NHTSA attempted to draw stronger conclusions by developing a statistical model but those results remain constrained by the information available to it. As noted above (see Section III.c), the Agency lacks data on many factors that may affect recall completion rates to varying degrees. For example, a large manufacturer might have a higher recall completion rate than a smaller manufacturer for a given recall. While true, the difference might be explained by information not available to NHTSA, such as the demographics of vehicle owners of that manufacturer, the

perceived risk of the defects, or the perceived costs of the remedies. The performance differential could also be impacted by the particular recalls issued between 2014 and 2018. If the Agency fit the same model to an earlier or later period of light vehicle recalls, the difference in recall completion rates between a large manufacturer and a smaller manufacturer could potentially increase or decrease—or disappear entirely.

Moreover, it is difficult for NHTSA to conclude that any manufacturer truly performed "better" than any other manufacturer, or that recalls for any particular component are truly problematic when considering lower than average completion rates. The figures that appear to support any such conclusion could potentially be explained by data not available in this analysis.

IV. ANNUAL RECALL COMPLETION RATES

a. Annual Rates by Manufacturer

Appendix A details the annual recall completion rates, by manufacturer, for light vehicle recalls issued between years 2014 and 2018. Forty-four manufacturers are detailed in the table located in Appendix A. However, the majority of light vehicles recalled between 2014 and 2018 (over 99%) were recalled by the major vehicle manufacturers which support NHTSA's VIN Look-up Tool found on www.NHTSA.gov/recalls.[3] Annual recall completion rates for these manufacturers are provided in the following figures.

[3] Manufacturers which support the Agency's VIN Look-up Tool are listed here: https://vinrcl.safercar.gov/vin/.

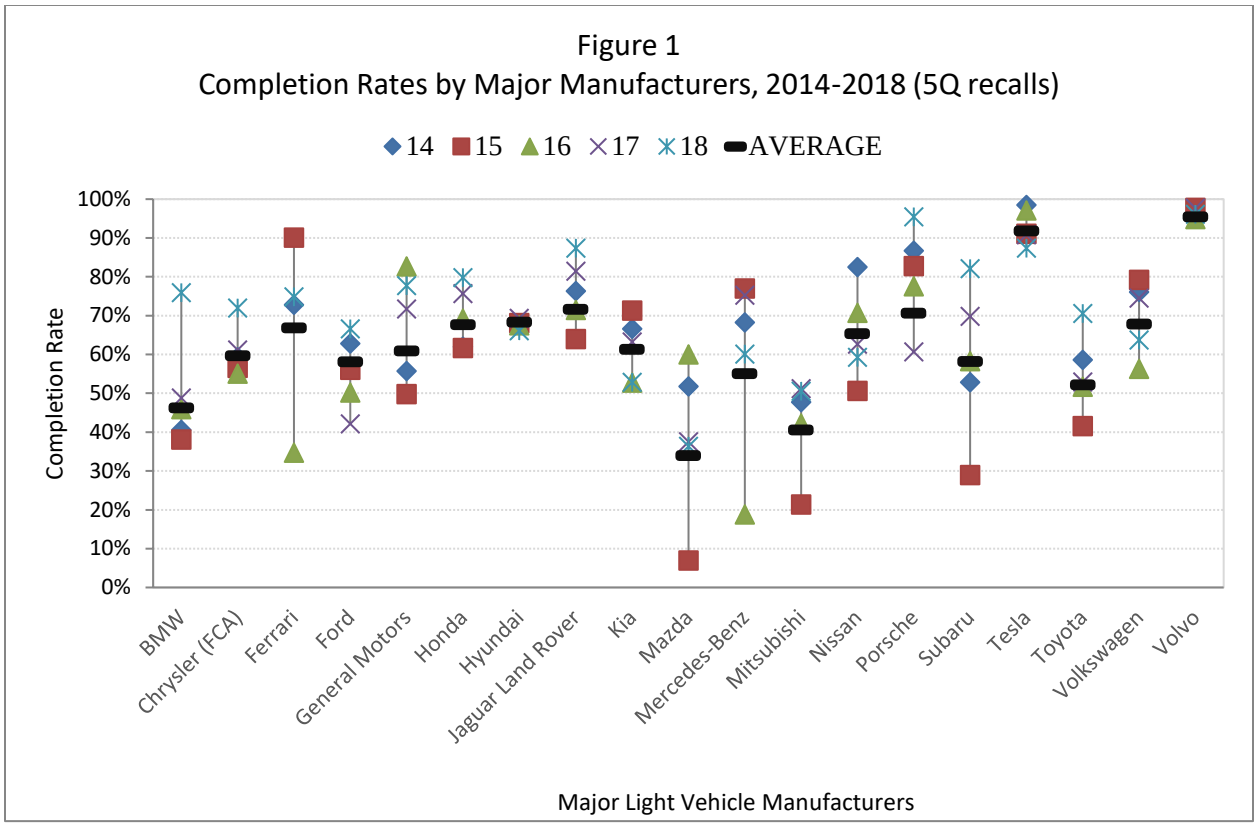
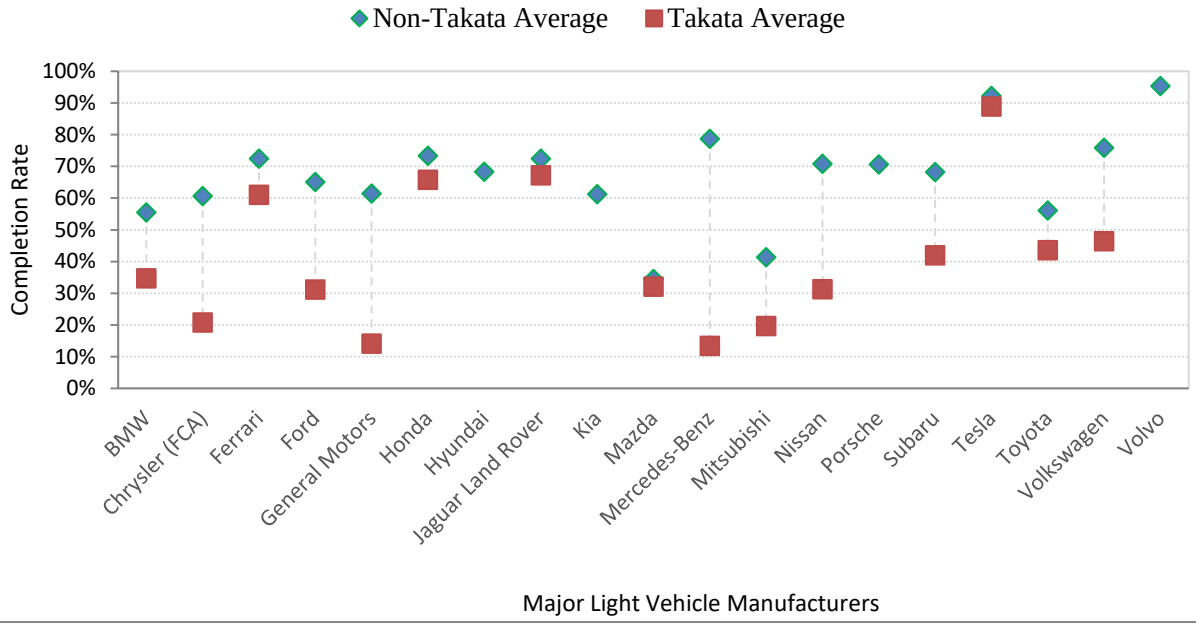


Figure 1 displays the major manufacturers of light vehicles and the ranges of their annual completion rates.[4] For these manufacturers, the combined weighted average annual completion rate is 59.8%, meaning more than 59% of all vehicles recalled were remedied. The average completion rate for eight of these manufacturers was the highest in 2018, the last available year of data for this report. Tesla and Volvo reached the highest annual completion rates with 91% and 95%, respectively, of their vehicles remedied during the period. Volvo achieved a 94% or greater completion rate in each of the four years in which it had a recall. The lowest annual completion rate was Mazda with approximately 7% of its vehicles being remedied for recalls issued in 2015. Note that this year was an outlier for Mazda, as the 2015 rate was pulled downward by a large recall (out of only 4 other recalls for Mazda vehicles) of very old vehicles

[4] Figure 1 does not imply any relationship between years.

affected by a potentially overheating ignition switch. In certain years, Mercedes, Mitsubishi, and Subaru also experienced relatively low completion rates under 30%. The weighted average for each manufacturer is included in Figure 1 to provide a more balanced indicator of performance over the five-year period.

Figure 1b
Non-Takata vs Takata-Only Average Completion Rates for 2014-2018 (5Q recalls)



As shown in Figure 1b, the massive Takata air bag recalls have had an impact on the completion averages for many of the major manufacturers' recall rates. Due to the size of the Takata recalls and the collective manufacturers' recall programs, replacement parts supply was a significant challenge. NHTSA, therefore, created a first of its kind Coordinated Remedy Program to prioritize the parts supply and organize a recall schedule based on risk, including vehicle age and exposure to sustained heat and humidity. Since 2018, Takata airbag recall completion rates have improved significantly.

As discussed in the first two reports to Congress, and in this report, the age of a vehicle at time of recall is a statistically significant and well-known predictor of whether a recalled vehicle is remedied. It is not surprising, therefore, that the high-volume Takata recalls launched during this period have had a demonstrable effect on lowering the average recall completion rates.[5]

Figure 1b shows the weighted average across the five-year span, for non-Takata campaigns and for Takata-only campaigns.[6] The adverse impact can be seen more readily when analyzing the rates by year and manufacturer. When considering all Nissan recall campaigns issued in 2015, for example, their completion rate is 50.6%. However, the percentage increases to 65.2% when considering only non-Takata campaigns for that same year. A similar, but more pronounced effect occurs with Subaru in 2015. All Subaru campaigns collectively achieved a relatively low rate of 29.0% in 2015, but without Takata campaigns included in that figure, the completion percentage is 85.1%.

This effect is not apparent with all manufacturers. As shown in Figure 1b, for Ferrari, Honda, Jaguar Land Rover, and Tesla most notably, the disparity between Takata completion rates and non-Takata campaign completion rates is minimal.

b. Annual Rates by Model Year

Figure 2 summarizes recall completion rates by vehicle model year for all light vehicle manufacturers. The summary shows a general trend in which newer model year vehicles are

[5] This impact was not observed in the Agency's first report because the set of recalls causing this impact had either not launched their remedy programs or had not reached an acceptable maturation threshold during the time frame considered in the last report to Congress.

[6] Some manufacturers did not have any mature Takata recalls, either because their recalls had not yet reached the fifth quarter of reporting or because the manufacturers were not part of the Takata recall.

more likely to be remedied than vehicles from older model years.[7] For example, a recall issued in 2013 for the 2013 Toyota Camry (when the vehicle was still very new) experienced an 88% completion rate. Conversely, a 2003 Toyota Camry recalled in 2013 (when the vehicle was 11 years old) experienced a 37% completion rate.

Figure 2
Completion Rates by Vehicle Model Year, 2014-2018 (5Q recalls)

	Year of Recall				
Model Year	**2014**	**2015**	**2016**	**2017**	**2018**
1989		0.6%			
1997	18.1%	33.1%			
1998		21.5%			
2000	57.8%	3.1%		23.0%	
2001	39.6%	57.5%	1.6%		85.3%
2002	33.7%	34.4%	49.8%	11.9%	60.2%
2003	61.8%	26.4%	38.7%	13.8%	20.5%
2004	47.0%	30.9%	13.8%	36.3%	32.8%
2005	48.8%	41.6%	62.5%	39.0%	10.0%
2006	54.2%	42.7%	52.9%	54.1%	61.2%
2007	32.2%	45.6%	50.1%	49.5%	42.7%
2008	67.1%	54.9%	48.3%	20.1%	38.5%
2009	82.3%	56.7%	49.3%	64.0%	55.8%
2010	69.2%	63.8%	52.5%	37.5%	71.2%
2011	72.6%	64.4%	66.1%	65.8%	62.4%
2012	82.4%	70.3%	66.6%	69.5%	74.8%
2013	76.6%	79.6%	70.9%	71.6%	62.4%
2014	89.2%	83.7%	84.5%	72.1%	72.8%
2015	89.9%	85.3%	87.1%	83.2%	71.4%
2016		91.4%	85.7%	79.2%	85.8%
2017			89.3%	90.7%	84.2%
2018				92.1%	91.9%
2019					91.5%
Grand Total	**58.4%**	**52.4%**	**63.3%**	**62.3%**	**68.6%**

[7] When a recall included multiple model years, the Agency used the age of the oldest vehicle in the recall for the model year categorization displayed in Figure 2. Boxes displaying as blank did not involve any model year vehicles in a recall that year.

One potential explanation for the disparity in recall completion rates between older and newer vehicles is the presence of new vehicle warranty programs. Vehicle owners may be more likely to visit a dealership during the warranty period and, as such, would have any outstanding safety recalls performed in the same visit. Figure 2b shows the same model year completion rate data, but grouped in ranges by the age of the oldest vehicle at the time of the recall.

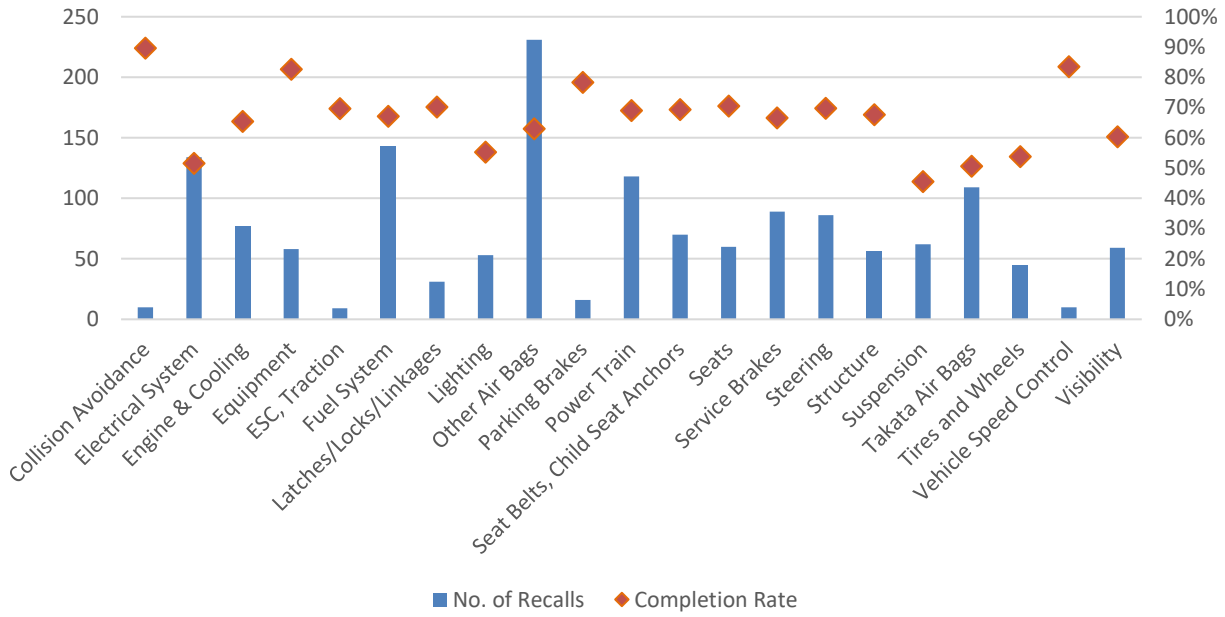
Figure 2b
Completion Rates by Age of Oldest Vehicle, 2014-2018 (5Q recalls)

	Year of Recall					
Oldest Vehicle Age Range	**2014**	**2015**	**2016**	**2017**	**2018**	Grand Total
0-3	78.61%	80.36%	78.76%	79.24%	79.09%	79.07%
4-9	62.44%	55.50%	56.41%	67.45%	66.21%	61.66%
10+	44.05%	41.91%	51.50%	44.48%	40.48%	44.75%
Grand Total	**58.40%**	**52.42%**	**63.28%**	**62.28%**	**68.62%**	59.79%

c. Annual Rates by Component

Figure 3 provides recall completion rates by component category. The recall completion rates for most component categories fall within a range of 60% to 70%. For example, of the over seven million vehicles recalled for "Power Train" issues across 118 recalls, 69.0% of those vehicles were repaired. Recalls for the component categories "Electrical System" and "Suspension" did not perform as well, with 51.5% and 45.5% of vehicles remedied for those issues, respectively. Appendix B provides component category completion rates by recall year. In Figure 3, the number of recalls for each component category is provided on the left-hand y-axis, while the completion rate is displayed on the right-hand y-axis.

Figure 3
Completion Rates by Recalled Component, 2014-2018 (5Q recalls)

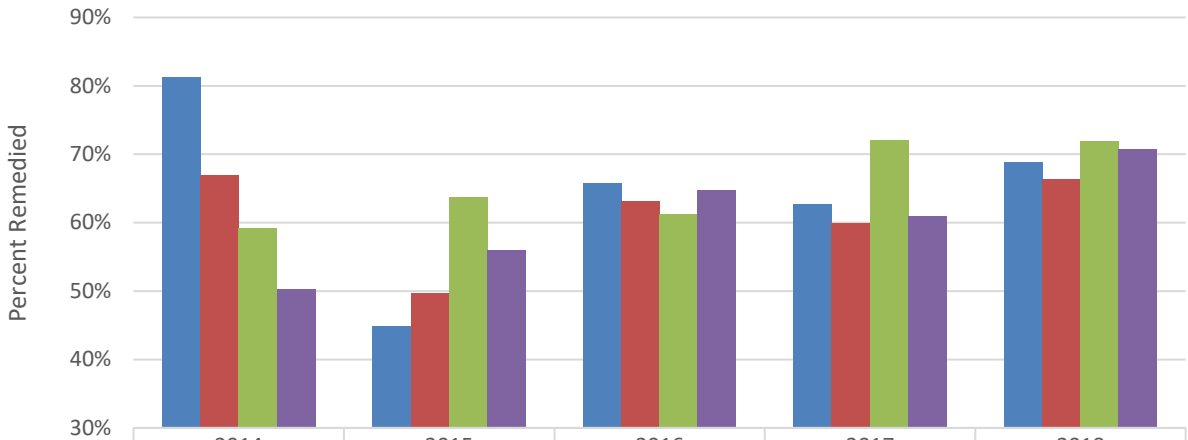


d. Annual Rates by Vehicle Type

Figure 4 depicts annual recall completion rates based on vehicle type. Approximately 19% of recalls include a mix of vehicle types, and those are represented in the "Mix" category. The annual recall completion rate for all vehicles combined ranged from 52% in 2015 to over 68% in 2018. Similarly, when examining the light vehicle recall types by year, there can be fairly significant fluctuations. For example, 67% of recalled, mixed-category vehicles were remedied in 2014, but only 50% in 2015, with an uptick to 63% in 2016.[8]

[8] Recalls for light trucks saw an 81% completion rate in 2014 primarily due to large recalls issued by General Motors for very new vehicles.

Figure 4
Completion Rates by Vehicle Mix, 2014-2018 (5Q recalls)



	2014	2015	2016	2017	2018
L. Truck	81.20%	44.81%	65.74%	62.62%	68.76%
Mixed	66.87%	49.68%	63.09%	59.90%	66.34%
MPV	59.23%	63.69%	61.18%	72.04%	71.93%
Pass. Car	50.30%	55.93%	64.76%	60.97%	70.65%

V. RECALL COMPLETION TRENDS AND SIGNIFICANT FACTORS

This report to Congress analyzes recall completion rates with respect to two objectives:

1) To identify factors that have a statistical impact on recall completion rates; and

2) To produce a model for future recall completion rates.

The results of this analysis are presented below.

a. Data Used

In order to try to get as accurate a statistical model as possible, we used data on more recalls than the 1,526 recalls used in Section IV. Specifically, we used the 2,171 mature light vehicle recalls that were initiated during 2010-2018.

Approximately 53% of the recalls analyzed in this report included vehicles of multiple model years.[9] As noted in Section III of this report, NHTSA does not receive a detailed itemization of recalled vehicles by model year, only an overall total. For recalls that included vehicles in multiple model years, only the oldest model year was considered in development of the model.

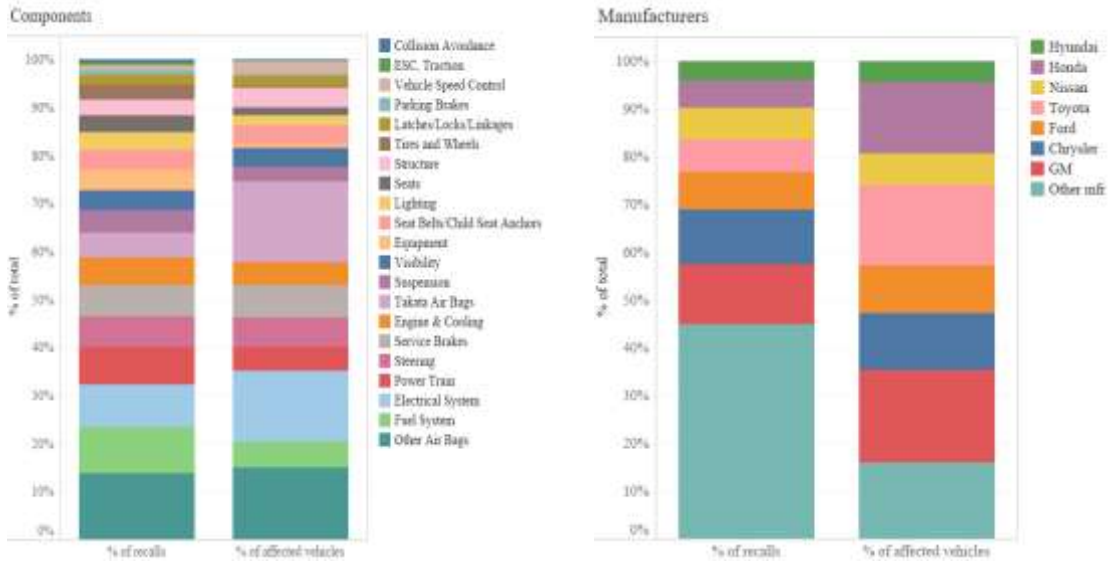
Approximately 14% of the recalls identified more than one defective component. To avoid the complications that would arise from considering multiple components, only the first listed component for these recalls was considered in the model.

b. Exploratory Analysis and Data Visualization

First, an exploratory analysis was conducted on the 2,171 light vehicle recalls conducted between 2010 and 2018. Figure 5 (shown below) provides an overview of which manufacturers issued the most recalls in this time period and how many recalls were issued. Figure 5 also illustrates the number of vehicles recalled and the number of recalls by component type:

[9] Because NHTSA lacks a breakdown of the number of affected vehicles by model year, NHTSA cannot compute the average age among affected vehicles.

Figure 5. Numbers of Recalls and Affected Vehicles by Manufacturer and Component



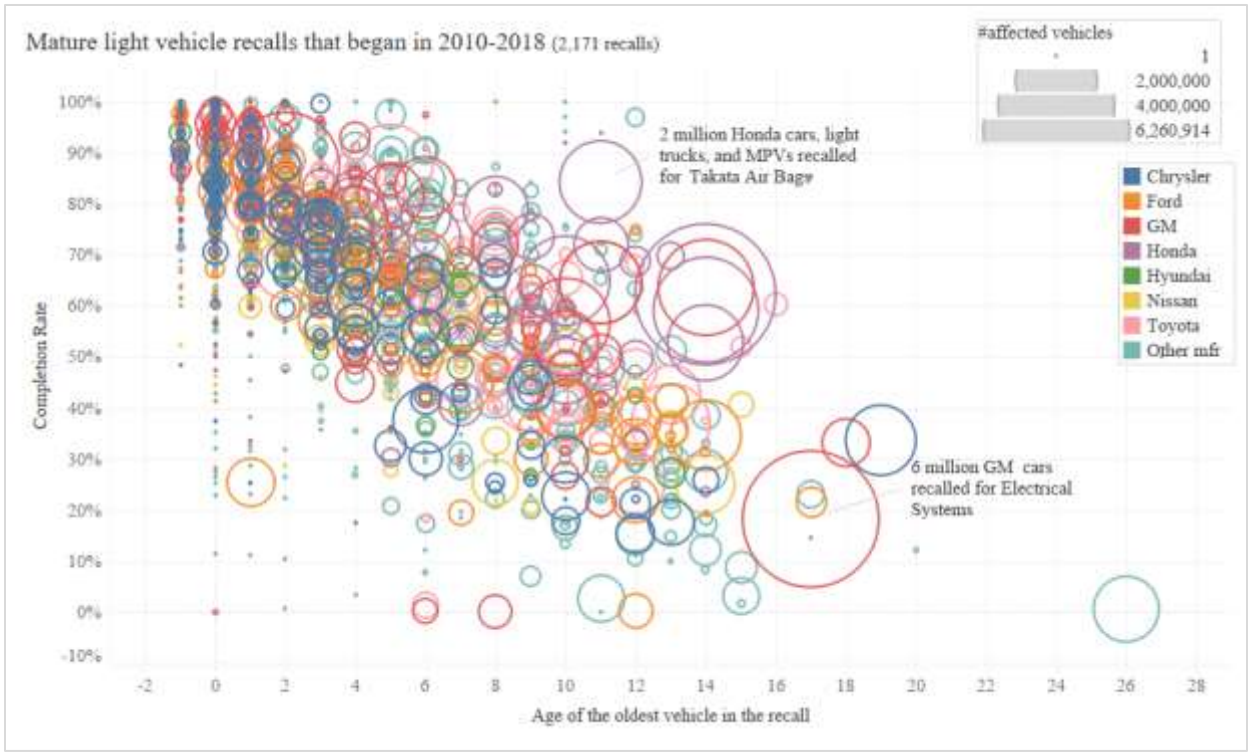
Totals: 2,171 recalls, affecting 237,769,976 vehicles

A significant number of vehicles recalled for this time period can be attributed to General Motors and Toyota recalls and the component categories “Electrical System,” “Takata Air Bags,” and “Other Air Bags.”

Although not depicted in Figure 5, or any figure, there is considerable variation in the size of recalls. More than a quarter of the recalls include less than 1,000 vehicles each; 3% of the recalls include more than 1 million vehicles each. Additionally, Figure 5 does not take into account the overall U.S. market share of each manufacturer, which may partially explain the numbers of vehicles recalled.

Figure 6 (shown below) depicts how vehicle age (based on the oldest vehicle involved in a given recall) correlates with recall completion rates. The bubbles presented in Figure 6 are scaled according to the number of vehicles involved in the recall. The six manufacturers identified in Figure 6 all conducted a recall involving more than 1 million vehicles between 2010 and 2017. Figure 6 shows a general downward trend in recall completion rates as the age of the recalled vehicles increases. Generally, recalls involving newer vehicles have higher recall completion rates than recalls involving older vehicles. The two labelled large bubbles to the right of the chart represent two million Honda vehicles recalled for Takata airbags in 2016 and another six million General Motors vehicles recalled for ignition switch defects in 2014. Together, these two recalls affected more than eight million vehicles, and some affected vehicles were up to 17 years old.

Figure 6: Recall Completion Rate by Age of Oldest Vehicle and Manufacturer



Of the 2,171 recalls examined in creating this model:

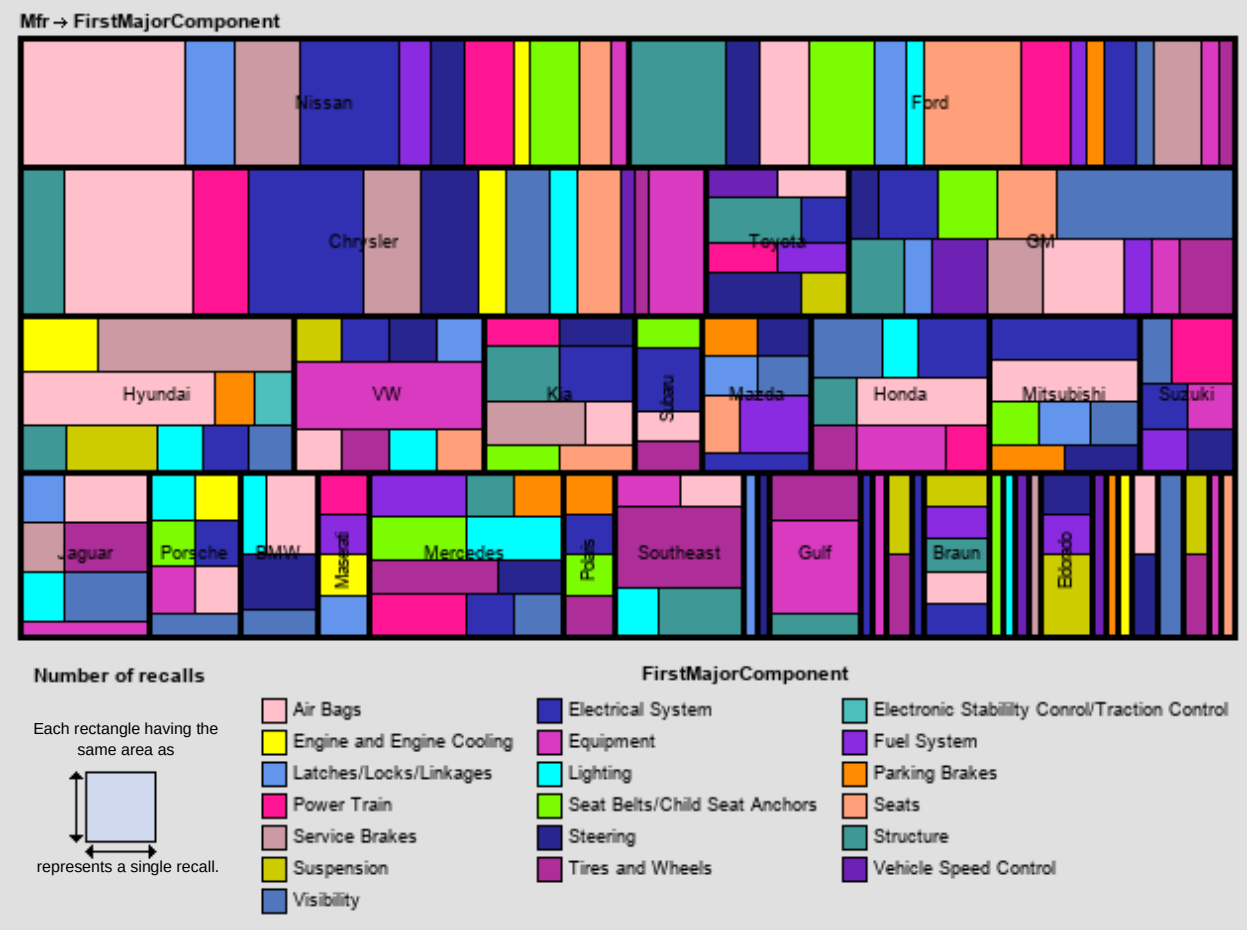
- 1,638 recalls (75%) were for vehicles four years or less of age when the recall was issued.
- 342 of these (21% of 1,638) had completion rates less than 75%.

As noted above, recalls involving these newer vehicles should have a relatively high recall completion rate, so it bears noting which recalls underperformed. As more data becomes available, NHTSA intends to use this metric to assist in applying its risk-based predictive modeling capabilities.

Figure 7 (shown below) illustrates the component categories identified in these recalls with a completion rate less than 75% and where the involved vehicles were four years old or less. These selections were chosen as a completion rate of 75% is generally an average completion rate, and these particular recalls, affecting newer vehicles, are generally expected to perform

higher than average. NHTSA understands that there are a variety of factors such as the vehicle owner having a recent relationship with a dealer or the vehicle being under warranty that could influence newer vehicles having higher completion rates, however, NHTSA does not have data to quantify the exact contributing factors. While air bag recalls appear to be prominent for a few manufacturers shown in Figure 7 (such as FCA and Nissan), a variety of component categories are identified in these under-performing recalls.

Figure 7
Recall Completion Rates Under 75% for Vehicles Less than 5 Years Old



c. Potential Factor Identification and Model Introduction

When examining the multiple variables associated with safety recalls, the Agency considered eleven factors for potential inclusion in the model:

1. The manufacturer;
2. The age of the oldest affected vehicle;
3. The vehicle type involved (i.e. passenger cars, lights trucks, MPVs);
4. The component category;
5. The recall safety risk description includes the word "crash";
6. The recall safety risk description includes the word "fire";
7. The recall safety risk description includes the word "death";
8. The recall safety risk description includes the word "injury";
9. The recall safety risk description includes the word "serious";
10. The year the recall was initiated; and
11. The number of vehicles affected by the recall.

NHTSA considered several families of statistical models, including a variety of generalized linear models. We applied both stepwise and LASSO (Least Absolute Shrinkage and Selection Operator) effect selection methods, and selected the final model via cross-validation. The result of this process was a fixed-effects logistic regression model with a Williams adjustment for over-dispersion, namely:

$$\ln \frac{r}{1-r} \sim \text{Age, Component, Manufacturer*Component} \qquad (1)$$

where *r* denotes the recall completion rate.[10] This is the predictive model NHTSA used to assess each factor's relative impact and to aid in projecting recall completion rates for future recalls.

[10] For further information on these types of models, effect selection, model selection, and the notation in Equation (1), we refer the reader to the following reference: SAS Institute Inc. 2017. *SAS/STAT® 14.3 User's Guide*. Cary, NC: SAS Institute Inc.

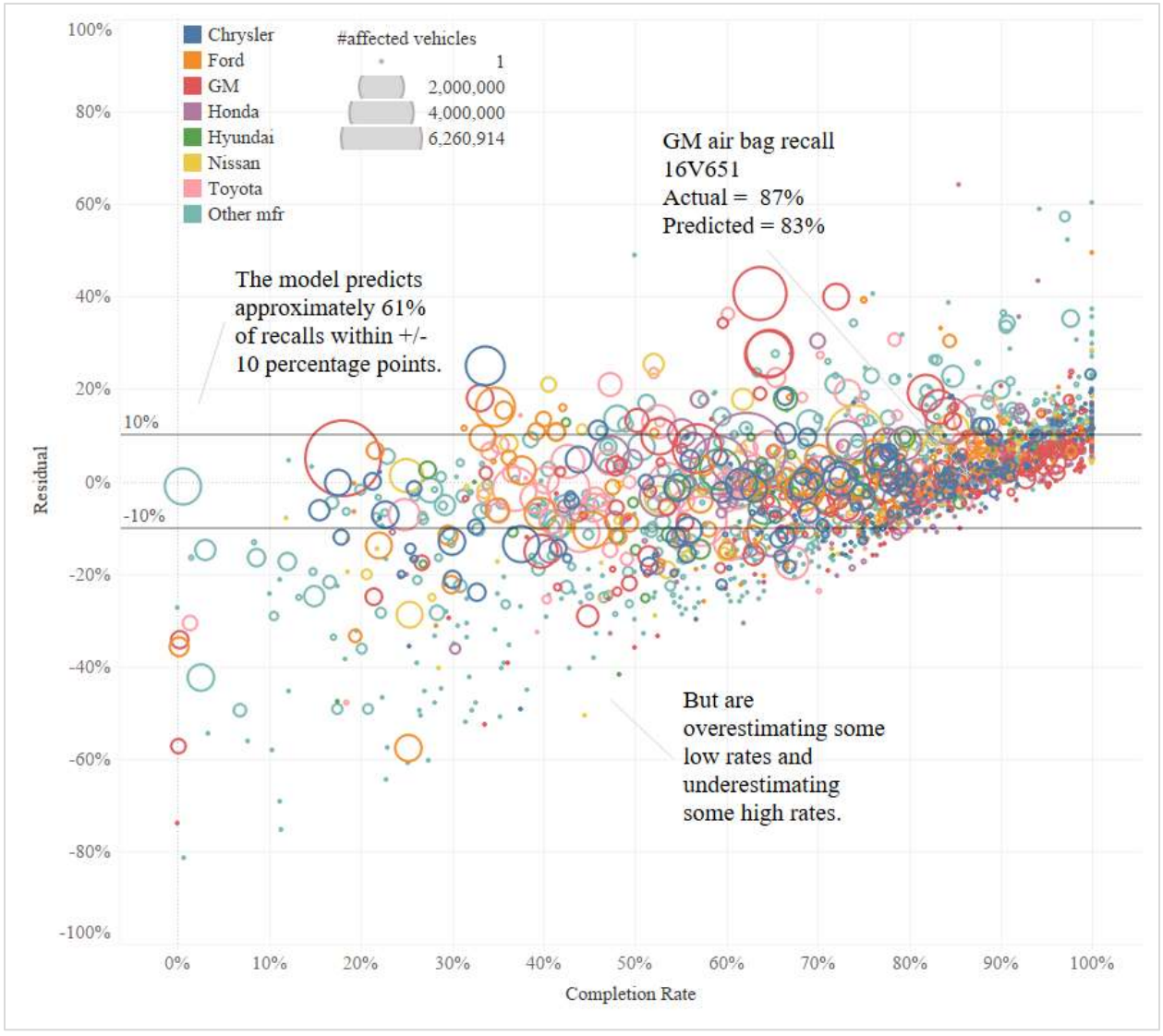
All 237,769,976 vehicles involved in recalls during the 2010-2018 time frame contributed equally to the model. Figure 8, located in Appendix C, presents standard statistical details for the model, including parameter estimates and standard errors.

d. Model Fit with Recall Completion Rates

Figure 9 (shown below) illustrates the model. Every data point indicates a separate recall. The figure shows that NHTSA's model generally fits the data, but it is not a perfect predictor of recall completion rates due to the limited data that NHTSA is able to collect, as previously discussed, and the inherently imperfect nature of modeling. When the 2,171 light vehicle recalls from 2010 through 2018 were analyzed, the model predicted the correct completion rate for 61% of those recalls, within plus or minus 10 percentage points. The model fit best for the "major" manufacturers, such as those found on NHTSA's VIN Look-up Tool. For these major manufacturers, the model correctly predicted 70% of recall completion rates within plus or minus 10 percentage points. On the other hand, many of the recalls where the predicted completion rates were off by more than 10 percentage points involved smaller manufacturers (labeled as "Other" in Figure 9).[11]

[11] We note that slightly different figures appeared in the 2018 Report to Congress, with the 2018 model doing slightly better at predicting the completion rate to within +/- 10 percentage points, both when we consider all manufacturers (63%) and when we consider the same figure for the non-"Other" manufacturers (73%). There are several metrics one can use to assess model fit, and the small differences we see here do not necessarily indicate that the current model fits the data any better or worse than the previous one did.

Figure 9. Model Fit at Predicting Recall Completion Rates



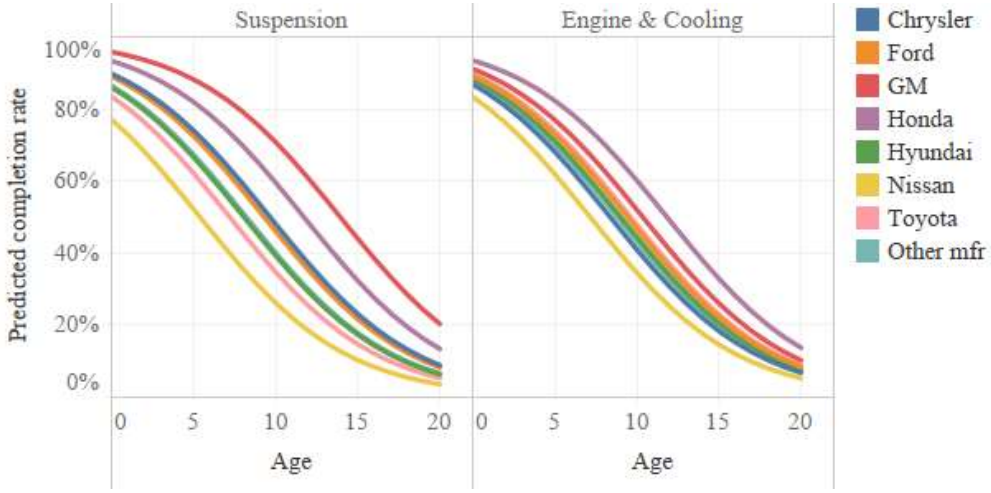
e. Model Results and Most Significant Factors

NHTSA's model involves only three factors – age, component, and manufacturer – and so we can visually depict the entire model in a relatively small number of graphs (namely, 21 graphs,

corresponding to NHTSA's 21 regulated component codes). The appendix contains all 21 graphs, and we illustrate two of them here: Suspensions, and Engine and Cooling.

The leftmost panel Figure 10 depicts the model's predictions for recalls involving suspension systems, while the right panel does the same for recalls involving engines and engine cooling. The model predicts recalls for suspensions on brand new vehicles (age 0) to have completion rates of 77% to 96% depending on the manufacturer. By the time these vehicles are 20 years old, their completion rates fall to 4% to 20%, again depending on the manufacturer. In contrast, the model predicts the completion rates for engine and engine cooling systems to have less variability by manufacturer, starting at 83%-93% at age 0 and falling to 5-14% at age 20 years. While the model predicts Nissan to have the lowest completion rates for both component categories, it predicts different best performers, with GM being best for suspension and Honda the best for engine and cooling.

Figure 10
The Model's Predictions for Recalls Involving Two Particular Component Categories



Here we are simply illustrating the results from two component categories. See the appendix for graphs depicting the model's predictions in the other 19 categories of components.

In this model the effect of manufacturer varies by component. This phenomenon is illustrated in the above Figure 10, in which the best-performing manufacturer was different for the two component categories.

The model shows three scenarios to have statistically significant effects on completion rates, namely:

1) The age of the oldest affected vehicle,
2) 69 differences between manufacturers for particular components, and
3) 204 differences between components for particular manufacturers

One way to understand the effects quantitatively is to discuss completion odds. The completion odds is defined as:

$$\text{Completion odds} = \frac{\text{completion rate}}{\text{100\%-completion rate}}$$

For instance, recall number 15V-320, which is for Takata air bags in Honda vehicles, had a completion rate of 62%. The completion odds for this recall is 62/38 = 1.6.

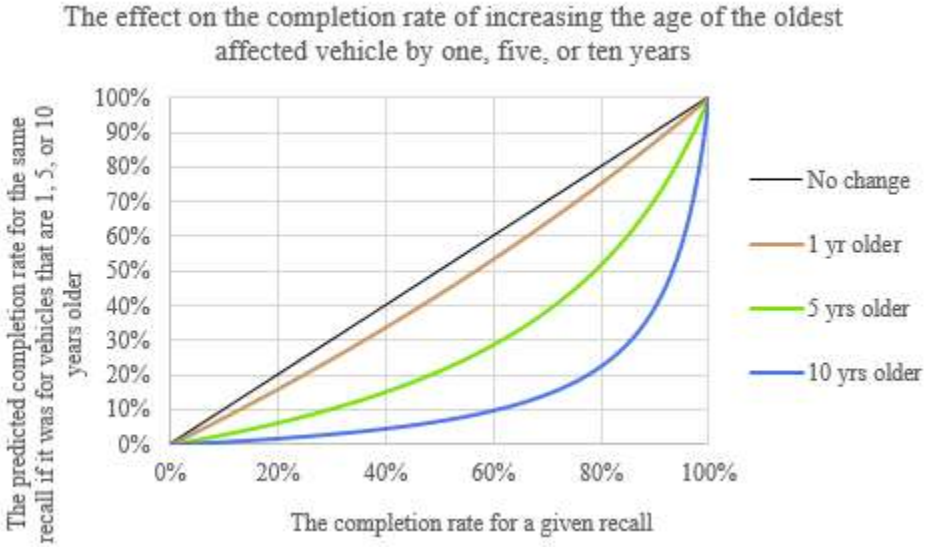
The effect of vehicle age is quantified as follows: Increasing the age of the oldest vehicle by one year reduces the completion odds by 23%. For instance, this same Honda recall (Honda Takata, completion rate=62%, completion odds = 1.6) was for 14+ year old vehicles. If it had been for 15+ year old vehicles, we would have expected its completion odds to be 1.6*0.77=1.2. This corresponds to a completion rate of 1.2/2.2= 55%.[12] Thus in this case, increasing vehicle age by

[12] The completion rate can be obtained from the completion odds via the formula: completion rate = x/(x+1), where x is the completion odds.

one year reduced the completion rate by seven percentage points. The percentage point reduction achieved will vary with the initial completion rate value.

Another way to understand the effect of age on completion rates is through the following graph, which shows the effect of increasing the age of the oldest vehicle in the recall by one, five, or ten years, keeping all other characteristics of the recall the same.

Figure 11



The graph indicates the dramatic effect of age, with for instance, a 5-year increase in age reducing a completion rate of 80% to nearly 50%. Note, however, that the available data cannot indicate the extent to which the vehicle age effect is truly a function of age or whether other factors—such as the demographics of owners of new vehicles or new vehicle warranty programs—play a significant role.

The model identifies 69 statistically significant differences[13] between manufacturers for particular components. For instance, Chrysler has a statistically higher completion rate for tires and wheels than Ford for vehicles of the same age. This is illustrated in the first line of Figure 12.

Figure 12
Statistically Significant Differences between Manufacturers for Particular Components

Manufacturer with the higher completion rate	***Manufacturer with the lower completion rate***	***The component for which the relationship holds***
Chrysler	Ford	Tires and Wheels
Chrysler	Ford	Equipment
GM	Chrysler	Other Air Bags
GM	Chrysler	Power Train
GM	Chrysler	Parking Brakes
GM	Ford	Power Train
GM	Ford	Seats
GM	Ford	Equipment
GM	Ford	Parking Brakes
GM	Hyundai	Other Air Bags
GM	Hyundai	Suspension
GM	Hyundai	Parking Brakes
GM	Nissan	Electrical System
GM	Nissan	Seat Belts/Child Seat Anchors
GM	Nissan	Other Air Bags
GM	Nissan	Power Train
GM	Nissan	Suspension
GM	Other mfr	Power Train
GM	Other mfr	Suspension
GM	Other mfr	Parking Brakes
GM	Toyota	Lighting
GM	Toyota	Suspension
Honda	Chrysler	Other Air Bags
Honda	Chrysler	Takata Air Bags
Honda	Ford	Other Air Bags
Honda	Ford	Fuel System
Honda	Ford	Takata Air Bags
Honda	GM	Takata Air Bags
Honda	Hyundai	Takata Air Bags
Honda	Hyundai	Other Air Bags
Honda	Nissan	Seat Belts/Child Seat Anchors

[13] The data to which the model was fit is a census (of all light vehicle recalls initiated during 2010-2017), and so the "statistical significance" here does not refer to sampling significance. Rather, it refers to significance in the model. For instance, in the Chrysler example, this means that controlling for vehicle age, the difference between Chrysler's and Ford's completion rates for tires and wheels is higher than we would expect to see under ordinary binomial variation (modeling the number of remedied vehicles for each manufacturer, component, and vehicle vintage as binomially distributed from the number of affected vehicles (number of trials) and a "true" completion rate).

Honda	Nissan	Takata Air Bags
Honda	Nissan	Other Air Bags
Honda	Other mfr	Takata Air Bags
Honda	Other mfr	Other Air Bags
Honda	Toyota	Lighting
Honda	Toyota	Takata Air Bags
Honda	Toyota	Other Air Bags
Hyundai	Ford	Seat Belts/Child Seat Anchors
Hyundai	Ford	Equipment
Hyundai	Nissan	Seat Belts/Child Seat Anchors
Nissan	Chrysler	Parking Brakes
Nissan	Ford	Parking Brakes
Nissan	Ford	Equipment
Nissan	Honda	Equipment
Nissan	Hyundai	Parking Brakes
Nissan	Other mfr	Parking Brakes
Nissan	Other mfr	Equipment
Other mfr	Chrysler	Other Air Bags
Other mfr	Ford	Equipment
Other mfr	GM	Takata Air Bags
Other mfr	Hyundai	Takata Air Bags
Other mfr	Nissan	Other Air Bags
Other mfr	Toyota	Lighting
Toyota	Chrysler	Other Air Bags
Toyota	Chrysler	Takata Air Bags
Toyota	Ford	Fuel System
Toyota	Ford	Tires and Wheels
Toyota	Ford	Equipment
Toyota	GM	Takata Air Bags
Toyota	GM	Vehicle Speed Control
Toyota	Honda	Vehicle Speed Control
Toyota	Hyundai	Vehicle Speed Control
Toyota	Hyundai	Takata Air Bags
Toyota	Nissan	Other Air Bags
Toyota	Nissan	Fuel System
Toyota	Nissan	Seat Belts/Child Seat Anchors
Toyota	Other mfr	Fuel System
Toyota	Other mfr	Vehicle Speed Control

The model also identifies 204 statistically significant differences between components for particular manufacturers. These are listed in Appendix D.

VI. SUMMARY OF FINDINGS

Based on the recall completion analysis provided in section IV and the statistical analysis that controlled for certain factors in section V, NHTSA has made the following findings:

• 60% of vehicles recalled by major light vehicle manufacturers between 2014 and 2018 were remedied by the fifth quarter of the recall. The lowest annual recall completion rate for the group as a whole during this period was 52% in 2015, and the highest annual recall completion rate was 69% in 2018.

• The age of the recalled vehicle plays a significant role in recall completion. Recalls for newer vehicles tend to have higher completion rates than recalls for older vehicles. For instance, increasing the age of the oldest vehicle in a given recall by 5 years could be expected to reduce a completion rate of 80% to below 60%.

• The model identified 69 scenarios where one manufacturer had a higher completion rate than another for a particular component, and the difference in completion rates was statistically significant. For instance, Chrysler (FCA) had a statistically higher completion rate for recalls involving tires and wheels than Ford for vehicles of the same age.

• Likewise, the model identified 204 scenarios where a particular manufacturer had statistically higher completion rates for one component versus another, controlling for vehicle age. For instance, Ford had a statistically higher completion rate for recalls involving electrical systems than recalls for equipment, for vehicles of the same age.

- NHTSA's model predicts 61% of recall completion rates accurately within a 10-percentage-point margin of error and predicts 70% of rates accurately for the major manufacturers examined in this analysis. This suggests that other factors relevant to recall completion rates are present but not identifiable with the available data.

VII. ACTIONS TO IMPROVE RECALL COMPLETION RATES

NHTSA strives each day to improve the safety recall process and to ensure as many owners as possible seek remedies for recalled vehicles. More specifically, the Agency is taking these actions or is evaluating these potentialities:

1) Development of predictive modeling guided by the statistical analysis in this report, particularly the significant findings noted above. This modeling, in conjunction with other analysis tools, will allow the Agency to better identify, with more expediency and accuracy, under-performing recalls and to work with manufacturers to improve their rates. It will also allow for identification of better performing recalls and closer examination of the reason(s) for their relative higher completion rates as compared to peer recalls. As the volume of recalls within the predictive model increases, the accuracy of the model will continue to pinpoint recall types with comparably lower completion rates.

2) Continued facilitation of sharing of information, such as best practices and lessons learned, for improving recalls completion. The continued oversight of the Takata recalls and the first-of-its kind coordinated remedy approach in particular, is expected to continue to inform the Agency, and then by extension, various automotive manufacturers and equipment suppliers that conduct or are otherwise directly involved in the execution of safety recalls. NHTSA will continue identifying opportunities to share information with manufacturers regarding recall best practices.

3) Communications outreach, such as NHTSA's new SaferCar app will allow for more public exposure of the continuing need to have recall-affected vehicles repaired. Additionally, NHTSA intends to continue to collaborate with manufacturers to ensure that existing consumer outreach methods and messages are effective and meet the needs of owners of affected vehicles.

Appendix A: Annual Recall Completion Rates by Vehicle Manufacturer

The table below provides the annual recall completion rate for manufacturers recalling light vehicles between 2010 and 2018. This table includes companies that modify new motor vehicles before their first retail sale (vehicle alterers), certain manufacturer distributors, and some low-volume, specialty manufacturers (such as limousine builders or electric vehicle manufacturers).

Manufacturer	2014	2015	2016	2017	2018	Total
Adrian	100.00%					100.00%
American					43.70%	43.70%
Aston	72.86%	73.00%		52.96%	89.97%	68.78%
Bentley		78.66%	75.45%		91.67%	78.48%
Bluecar			100.00%	100.00%		100.00%
BMW	40.56%	38.06%	45.91%	48.80%	75.90%	46.24%
Braun		99.88%	35.25%	31.49%	61.67%	64.23%
Bugatti			95.93%	100.00%	100.00%	96.15%
Chrysler	59.26%	56.54%	55.04%	61.20%	71.97%	59.62%
Daimler			30.59%	32.54%		31.23%
Eldorado		52.24%	28.07%	27.77%		28.46%
Ferrari	72.78%	90.06%	34.75%		74.83%	66.82%
Ford	62.85%	56.09%	50.19%	42.13%	66.59%	58.05%
Freedom	31.54%					31.54%
GM	55.73%	49.76%	82.68%	71.73%	77.72%	60.90%
Gulf	78.43%	61.76%	92.85%	63.53%		76.82%
Honda	61.99%	61.62%	69.27%	75.64%	79.78%	67.62%
Hyundai	67.87%	68.08%	67.53%	69.35%	66.11%	68.28%
Jaguar	76.37%	63.98%	71.43%	81.42%	87.39%	71.59%
Karma				57.46%	97.22%	63.46%
Kia	66.57%	71.26%	52.72%	63.22%	52.85%	61.30%
Koenigsegg	100.00%					100.00%
Lamborghini				84.02%	58.31%	66.94%
Lotus	31.66%				91.67%	34.08%
Maserati	100.00%	87.76%	82.90%	78.05%	66.15%	79.56%
Mazda	51.76%	6.93%	60.03%	37.53%	36.36%	33.90%
McLaren		93.44%		94.96%	90.04%	93.04%
Mercedes	68.29%	76.97%	18.79%	75.26%	60.08%	55.06%
Mitsubishi	47.75%	21.39%	42.25%	51.22%	50.56%	40.56%
Mobility				35.03%		35.03%
Nissan	82.51%	50.60%	70.75%	62.62%	59.31%	65.32%
Pagani			100.00%		100.00%	100.00%
Phoenix				100.00%		100.00%
Polaris		25.80%	75.79%	61.32%	37.99%	45.50%
Porsche	86.74%	82.78%	77.53%	60.70%	95.44%	70.62%

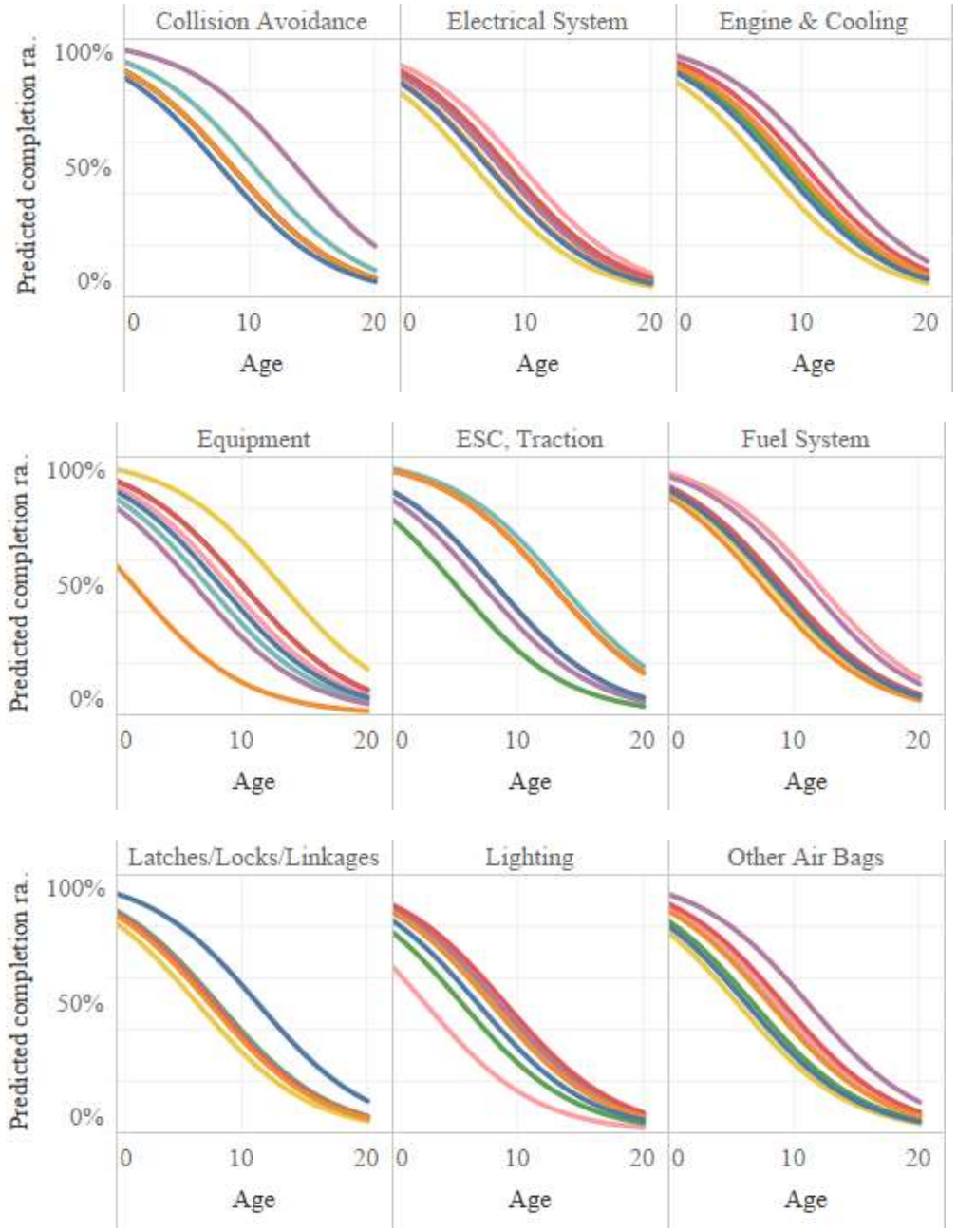
Roush		22.78%		98.85%		59.66%
Southeast	47.64%	55.12%	47.96%	44.33%	95.98%	50.37%
Subaru	52.88%	28.96%	58.31%	69.83%	82.07%	58.18%
Suzuki	27.00%	54.09%		29.33%	43.40%	28.93%
Tesla	98.48%	91.09%	97.12%	90.84%	87.34%	91.77%
Toyota	58.62%	41.51%	51.65%	52.96%	70.55%	52.16%
Vantage				84.92%		84.92%
Volvo		97.78%	94.90%	97.65%	96.12%	95.37%
VW	76.10%	79.19%	56.26%	74.47%	63.70%	67.78%
Westward	100.00%					100.00%
Total	58.40%	52.42%	63.28%	62.28%	68.62%	59.79%

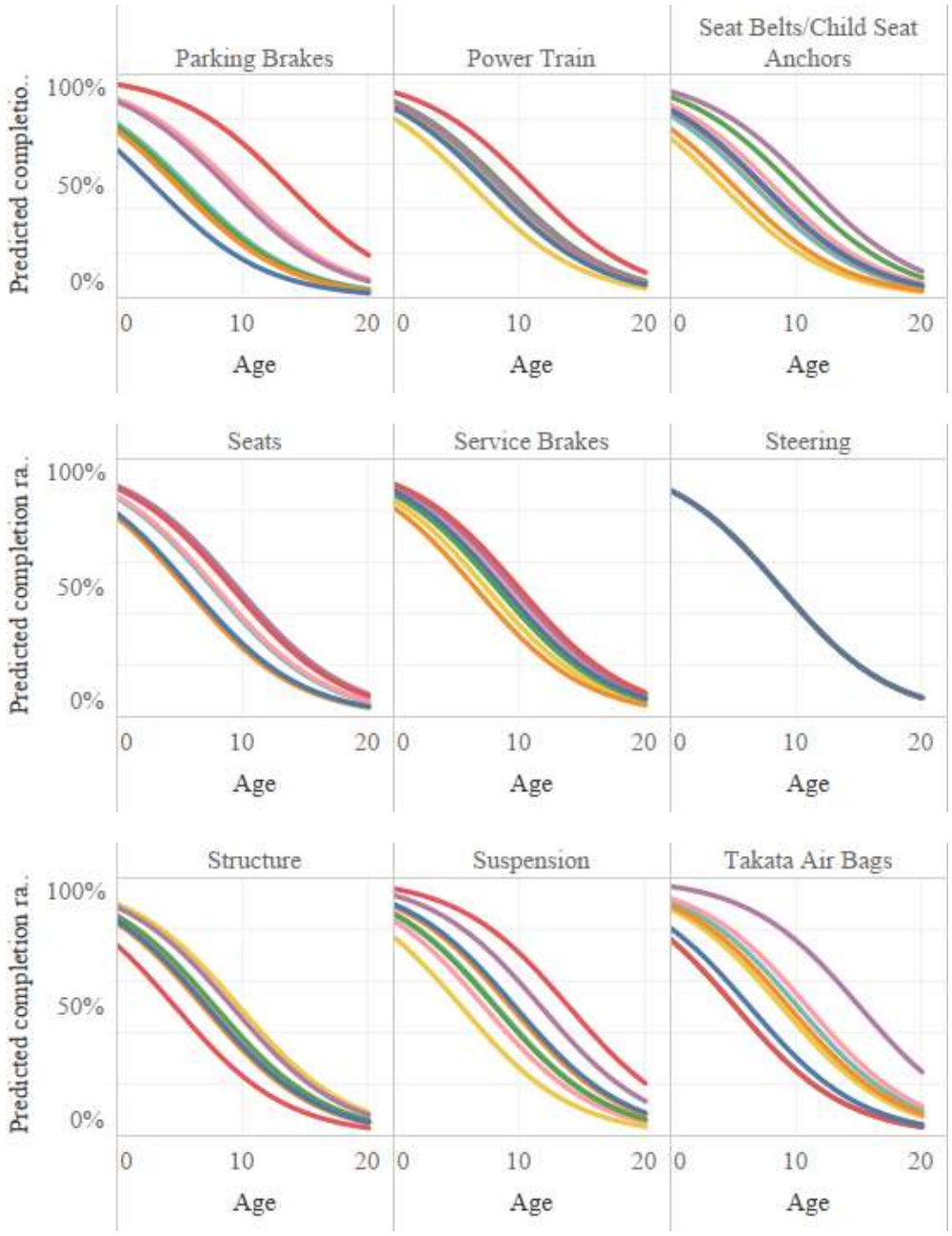
Appendix B: Annual Recall Completion Rates by Component

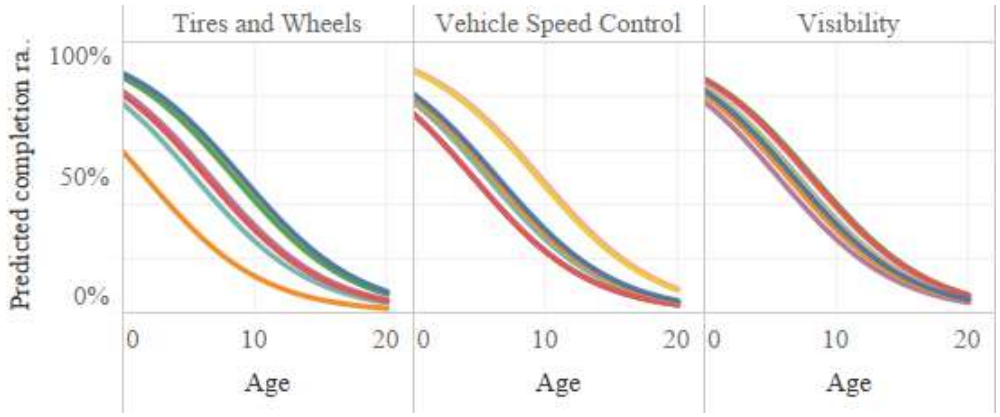
Component Category	2014	2015	2016	2017	2018
Collision Avoidance		86.8%	87.9%	94.4%	87.4%
Electrical System	49.0%	43.6%	59.7%	69.1%	82.2%
Engine & Cooling	78.9%	48.8%	82.7%	68.5%	71.9%
Equipment	65.6%	91.4%	80.6%	96.6%	59.1%
ESC, Traction	84.4%	56.0%	94.5%	91.7%	
Fuel System	63.9%	72.4%	62.9%	63.1%	72.8%
Latches/Locks/Linkages	77.4%	72.3%	65.3%	73.5%	63.7%
Lighting	52.9%	50.9%	83.5%	93.5%	91.4%
Other Air Bags	66.4%	45.2%	70.0%	57.4%	67.4%
Parking Brakes	96.1%	79.7%	88.4%	69.1%	54.9%
Power Train	68.7%	70.3%	71.9%	64.4%	67.8%
Seat Belts, Child Seat Anchors	81.2%	61.7%	63.6%	70.6%	72.8%
Seats	63.9%	90.4%	76.6%	69.1%	82.8%
Service Brakes	63.1%	63.9%	77.0%	60.7%	78.4%
Steering	62.8%	69.3%	76.3%	70.9%	76.2%
Structure	63.9%	72.4%	60.4%	76.7%	71.2%
Suspension	53.3%	34.2%	43.5%	40.7%	34.9%
Takata Air Bags	27.7%	48.5%	53.0%	44.4%	59.7%
Tires and Wheels	49.3%	79.5%	84.2%	95.7%	93.4%
Vehicle Speed Control	85.6%	83.3%	83.0%	88.9%	90.0%
Visibility	68.1%	52.8%	67.3%	74.5%	68.3%

Appendix C

Below are charts depicting the completion rate model. There is one chart (panel) for each component category in the model.




Parking Brakes
Power Train
Seat Belts/Child Seat Anchors
Seats
Service Brakes
Steering
Structure
Suspension
Takata Air Bags
Predicted completio..
Predicted completion ra..
100%
50%
0%
0
10
20
Age


Tires and Wheels
Vehicle Speed Control
Visibility
Predicted completion ra.
100%
50%
0%
0
10
20
Age

Appendix D

The following table presents the coefficients for the Williams-adjusted fixed effect logistic model used in Section V.

Variable	*Class Level 1*	*Class Level 2*	*df*	*Estimate*	*Standard Error*	*Wald Chi-Square*	*Pr > Chi-Square*
Intercept			1	1.97	0.08	553.96	0.00
Age			1	-0.23	0.01	1433.50	0.00
Compt	Collision Avoidance		1	-0.02	0.93	0.00	0.98
	ESC, Traction		1	0.89	0.89	1.00	0.32
	Electrical System		1	-0.03	0.18	0.02	0.89
	Engine & Cooling		1	0.36	0.34	1.13	0.29
	Equipment		1	0.30	0.38	0.62	0.43
	Fuel System		1	0.07	0.23	0.08	0.78
	Latches/Locks/ Linkages		1	-0.25	0.55	0.22	0.64
	Lighting		1	0.06	0.40	0.02	0.89
	Other Air Bags		1	0.09	0.19	0.24	0.63
	Parking Brakes		1	1.08	0.68	2.51	0.11
	Power Train		1	0.47	0.26	3.28	0.07
	Seat Belts/Child Seat Anchors		1	-0.33	0.21	2.54	0.11
	Seats		1	0.08	0.30	0.08	0.78
	Service Brakes		1	0.27	0.25	1.15	0.28
	Structure		1	-0.93	0.37	6.27	0.01
	Suspension		1	1.17	0.49	5.61	0.02
	Takata Air Bags		1	-0.81	0.56	2.08	0.15
	Tires and Wheels		1	-0.55	0.38	2.04	0.15
	Vehicle Speed Control		1	-0.95	0.46	4.29	0.04
	Visibility		1	-0.15	0.22	0.49	0.48
Mfr*Compt	Chrysler	Collision Avoidance	1	-0.21	1.36	0.02	0.88
		ESC, Traction	1	-1.00	1.08	0.86	0.35
		Electrical System	1	-0.36	0.21	2.78	0.10
		Engine & Cooling	1	-0.45	0.42	1.14	0.29
		Equipment	1	-0.40	0.46	0.78	0.38
		Fuel System	1	-0.12	0.39	0.09	0.76
		Latches/Locks/Linkages	1	0.82	1.00	0.68	0.41
		Lighting	1	-0.50	0.56	0.79	0.38
		Other Air Bags	1	-0.66	0.21	9.62	0.00
		Parking Brakes	1	-2.38	0.81	8.58	0.00
		Power Train	1	-0.72	0.29	6.20	0.01
		Seat Belts/Child Seat Anchors	1	0.04	0.74	0.00	0.96
		Seats	1	-0.74	0.45	2.71	0.10
		Service Brakes	1	-0.29	0.33	0.76	0.38
		Structure	1	0.57	0.49	1.35	0.25

Variable	*Class Level 1*	*Class Level 2*	*df*	*Estimate*	*Standard Error*	*Wald Chi-Square*	*Pr > Chi-Square*
		Suspension	1	-0.96	0.62	2.44	0.12
		Takata Air Bags	1	0.26	0.71	0.13	0.71
		Tires and Wheels	1	0.61	0.56	1.21	0.27
		Vehicle Speed Control	1	0.41	0.67	0.38	0.54
		Visibility	1	-0.29	0.41	0.49	0.48
	Ford	Collision Avoidance	0	0.00			
		ESC, Traction	0	0.00			
		Electrical System	1	-0.32	0.35	0.82	0.37
		Engine & Cooling	1	-0.21	0.50	0.18	0.68
		Equipment	1	-1.96	0.66	8.91	0.00
		Fuel System	1	-0.35	0.28	1.53	0.22
		Latches/Locks/Linkages	1	-0.04	0.64	0.00	0.95
		Lighting	1	-0.25	0.55	0.21	0.65
		Other Air Bags	1	-0.25	0.31	0.63	0.43
		Parking Brakes	1	-1.98	0.89	4.91	0.03
		Power Train	1	-0.69	0.32	4.83	0.03
		Seat Belts/Child Seat Anchors	1	-0.51	0.36	1.93	0.16
		Seats	1	-0.83	0.39	4.56	0.03
		Service Brakes	1	-0.78	0.41	3.59	0.06
		Structure	1	0.50	0.43	1.37	0.24
		Suspension	1	-1.04	0.62	2.85	0.09
		Takata Air Bags	1	0.96	0.60	2.53	0.11
		Tires and Wheels	1	-1.04	0.64	2.65	0.10
		Vehicle Speed Control	1	0.33	0.99	0.11	0.74
		Visibility	1	-0.39	0.46	0.72	0.40
	Honda	Collision Avoidance	1	1.14	1.83	0.39	0.53
		ESC, Traction	1	-1.25	1.26	0.99	0.32
		Electrical System	1	-0.14	0.26	0.27	0.60
		Engine & Cooling	1	0.33	0.58	0.33	0.57
		Equipment	1	-0.87	0.52	2.73	0.10
		Fuel System	1	0.47	0.42	1.21	0.27
		Latches/Locks/Linkages	1	0.06	0.90	0.00	0.95
		Lighting	1	-0.12	0.56	0.05	0.83
		Other Air Bags	1	0.44	0.26	2.93	0.09
		Parking Brakes	1	-1.08	1.29	0.70	0.40
		Power Train	1	-0.51	0.39	1.68	0.20
		Seat Belts/Child Seat Anchors	1	0.85	0.69	1.52	0.22
		Seats	1	0.10	0.50	0.04	0.84
		Service Brakes	1	-0.09	0.44	0.05	0.83
		Structure	1	1.02	0.63	2.57	0.11
		Suspension	1	-0.50	0.80	0.39	0.53
		Takata Air Bags	1	2.22	0.60	13.54	0.00
		Tires and Wheels	1	0.08	0.65	0.02	0.90
		Vehicle Speed Control	0	0.00			
		Visibility	1	-0.56	0.41	1.84	0.17
	Hyundai	Collision Avoidance	0	0.00			
		ESC, Traction	1	-1.72	1.14	2.27	0.13
		Electrical System	1	0.00	0.56	0.00	1.00
		Engine & Cooling	1	-0.30	0.54	0.32	0.57

Variable	*Class Level 1*	*Class Level 2*	*df*	*Estimate*	*Standard Error*	*Wald Chi-Square*	*Pr > Chi-Square*
		Equipment	0	0.00			
		Fuel System	1	-0.05	0.47	0.01	0.92
		Latches/Locks/Linkages	1	0.10	0.70	0.02	0.88
		Lighting	1	-0.78	0.55	1.99	0.16
		Other Air Bags	1	-0.54	0.26	4.46	0.03
		Parking Brakes	1	-1.86	0.88	4.43	0.04
		Power Train	1	-0.46	0.45	1.03	0.31
		Seat Belts/Child Seat Anchors	1	0.55	0.47	1.38	0.24
		Seats	1	-0.77	0.82	0.88	0.35
		Service Brakes	1	-0.40	0.36	1.23	0.27
		Structure	1	0.72	0.86	0.69	0.40
		Suspension	1	-1.32	0.59	5.01	0.03
		Takata Air Bags	0	0.00			
		Tires and Wheels	1	0.47	0.75	0.40	0.53
		Vehicle Speed Control	0	0.00			
		Visibility	1	0.04	0.47	0.01	0.93
	Nissan	Collision Avoidance	0	0.00			
		ESC, Traction	0	0.00			
		Electrical System	1	-0.61	0.31	3.88	0.05
		Engine & Cooling	1	-0.72	0.54	1.76	0.18
		Equipment	1	0.70	0.68	1.07	0.30
		Fuel System	1	-0.19	0.30	0.41	0.52
		Latches/Locks/Linkages	1	-0.26	0.64	0.17	0.68
		Lighting	1	-0.16	0.93	0.03	0.86
		Other Air Bags	1	-0.82	0.23	12.28	0.00
		Parking Brakes	0	0.00			
		Power Train	1	-1.03	0.42	6.07	0.01
		Seat Belts/Child Seat Anchors	1	-0.72	0.36	3.98	0.05
		Seats	1	-0.77	0.53	2.14	0.14
		Service Brakes	1	-0.59	0.33	3.08	0.08
		Structure	1	1.14	0.62	3.39	0.07
		Suspension	1	-1.92	0.60	10.23	0.00
		Takata Air Bags	1	0.82	0.62	1.78	0.18
		Tires and Wheels	1	0.54	0.73	0.55	0.46
		Vehicle Speed Control	1	1.09	0.87	1.58	0.21
		Visibility	1	-0.25	0.97	0.07	0.79
	Other mfr	Collision Avoidance	1	0.39	1.01	0.15	0.70
		ESC, Traction	1	0.17	1.21	0.02	0.89
		Electrical System	1	-0.11	0.19	0.34	0.56
		Engine & Cooling	1	-0.35	0.35	1.02	0.31
		Equipment	1	-0.63	0.39	2.56	0.11
		Fuel System	1	0.01	0.24	0.00	0.96
		Latches/Locks/Linkages	1	-0.01	0.58	0.00	0.98
		Lighting	1	-0.25	0.42	0.38	0.54
		Other Air Bags	1	-0.21	0.19	1.16	0.28
		Parking Brakes	1	-1.78	0.74	5.81	0.02
		Power Train	1	-0.58	0.28	4.30	0.04
		Seat Belts/Child Seat Anchors	1	-0.15	0.25	0.36	0.55

Variable	*Class Level 1*	*Class Level 2*	*df*	*Estimate*	*Standard Error*	*Wald Chi-Square*	*Pr > Chi-Square*
		Seats	1	-0.33	0.34	0.95	0.33
		Service Brakes	1	-0.32	0.27	1.41	0.24
		Structure	1	0.61	0.39	2.42	0.12
		Suspension	1	-1.29	0.50	6.59	0.01
		Takata Air Bags	1	1.12	0.56	3.96	0.05
		Tires and Wheels	1	-0.20	0.40	0.25	0.62
		Vehicle Speed Control	1	0.24	0.54	0.19	0.66
		Visibility	1	-0.21	0.24	0.76	0.38
	Toyota	Collision Avoidance	0	0.00			
		ESC, Traction	1	-1.01	1.07	0.90	0.34
		Electrical System	1	0.24	0.39	0.38	0.54
		Engine & Cooling	1	-0.17	0.45	0.14	0.71
		Equipment	1	-0.25	0.55	0.20	0.65
		Fuel System	1	0.66	0.35	3.52	0.06
		Latches/Locks/Linkages	0	0.00			
		Lighting	1	-1.44	0.65	4.83	0.03
		Other Air Bags	1	-0.10	0.25	0.17	0.68
		Parking Brakes	1	-0.95	1.08	0.78	0.38
		Power Train	1	-0.71	0.37	3.60	0.06
		Seat Belts/Child Seat Anchors	1	0.20	0.35	0.31	0.58
		Seats	1	-0.28	0.58	0.24	0.63
		Service Brakes	1	-0.16	0.38	0.19	0.66
		Structure	1	0.63	0.54	1.33	0.25
		Suspension	1	-1.52	0.55	7.53	0.01
		Takata Air Bags	1	1.29	0.60	4.61	0.03
		Tires and Wheels	1	0.51	0.54	0.86	0.35
		Vehicle Speed Control	1	1.15	0.56	4.16	0.04
		Visibility	1	-0.03	0.40	0.01	0.94

Appendix E

The following table lists the 204 statistically differences between components for particular manufacturers. For instance, the fourth line of the table conveys that Ford has higher completion rates for electrical systems than for equipment, controlling for the age of the oldest vehicle in the recall.

Statistically significant difference among components for particular manufacturers

The component with the higher completion rate	***The component with the lower completion rate***	***The manufacturer for which this holds***
Collision Avoidance	Parking Brakes	Other mfr
Collision Avoidance	Tires and Wheels	Other mfr
Collision Avoidance	Vehicle Speed Control	Other mfr
Electrical System	Equipment	Ford
Electrical System	Lighting	Toyota
Electrical System	Structure	GM
Electrical System	Tires and Wheels	Ford
Electrical System	Tires and Wheels	Other mfr
Engine & Cooling	Equipment	Ford
Engine & Cooling	Equipment	Honda
Engine & Cooling	Lighting	Toyota
Engine & Cooling	Parking Brakes	Chrysler
Engine & Cooling	Parking Brakes	Other mfr
Engine & Cooling	Seat Belts/Child Seat Anchors	Ford
Engine & Cooling	Seat Belts/Child Seat Anchors	Other mfr
Engine & Cooling	Structure	GM
Engine & Cooling	Tires and Wheels	Ford
Engine & Cooling	Tires and Wheels	Other mfr
Engine & Cooling	Vehicle Speed Control	Honda
Engine & Cooling	Vehicle Speed Control	GM
Engine & Cooling	Vehicle Speed Control	Other mfr
Engine & Cooling	Visibility	Honda
Engine & Cooling	Visibility	Other mfr
Equipment	Electrical System	Nissan
Equipment	Latches/Locks/Linkages	Nissan
Equipment	Lighting	Toyota
Equipment	Other Air Bags	Nissan
Equipment	Parking Brakes	Chrysler
Equipment	Power Train	Nissan
Equipment	Seat Belts/Child Seat Anchors	Nissan
Equipment	Seats	Nissan
Equipment	Service Brakes	Nissan
Equipment	Structure	GM
Equipment	Suspension	Nissan
Equipment	Tires and Wheels	Other mfr

The component with the higher completion rate	*The component with the lower completion rate*	*The manufacturer for which this holds*
Equipment	Vehicle Speed Control	Hyundai
Equipment	Vehicle Speed Control	GM
ESC, Traction	Parking Brakes	Other mfr
ESC, Traction	Seat Belts/Child Seat Anchors	Nissan
ESC, Traction	Tires and Wheels	Ford
ESC, Traction	Tires and Wheels	Other mfr
ESC, Traction	Vehicle Speed Control	Other mfr
Fuel System	Equipment	Other mfr
Fuel System	Equipment	Honda
Fuel System	Equipment	Ford
Fuel System	Lighting	Toyota
Fuel System	Other Air Bags	Toyota
Fuel System	Other Air Bags	Nissan
Fuel System	Parking Brakes	Chrysler
Fuel System	Parking Brakes	Other mfr
Fuel System	Power Train	Toyota
Fuel System	Seat Belts/Child Seat Anchors	Nissan
Fuel System	Seat Belts/Child Seat Anchors	Toyota
Fuel System	Seat Belts/Child Seat Anchors	Other mfr
Fuel System	Steering	Toyota
Fuel System	Structure	Toyota
Fuel System	Structure	GM
Fuel System	Structure	Other mfr
Fuel System	Suspension	Toyota
Fuel System	Tires and Wheels	Ford
Fuel System	Tires and Wheels	Other mfr
Fuel System	Vehicle Speed Control	Honda
Fuel System	Vehicle Speed Control	GM
Fuel System	Vehicle Speed Control	Other mfr
Fuel System	Visibility	Honda
Fuel System	Visibility	Toyota
Fuel System	Visibility	Other mfr
Latches/Locks/Linkages	Equipment	Ford
Latches/Locks/Linkages	Tires and Wheels	Ford
Lighting	Equipment	Ford
Lighting	Tires and Wheels	Ford
Lighting	Tires and Wheels	Other mfr
Other Air Bags	Electrical System	Honda
Other Air Bags	Equipment	Honda
Other Air Bags	Equipment	Ford
Other Air Bags	Lighting	Toyota
Other Air Bags	Seat Belts/Child Seat Anchors	Other mfr
Other Air Bags	Steering	Honda
Other Air Bags	Structure	GM
Other Air Bags	Tires and Wheels	Ford
Other Air Bags	Tires and Wheels	Other mfr
Other Air Bags	Vehicle Speed Control	Honda
Other Air Bags	Vehicle Speed Control	GM
Other Air Bags	Vehicle Speed Control	Other mfr
Other Air Bags	Visibility	Honda
Parking Brakes	Electrical System	Nissan

The component with the higher completion rate	*The component with the lower completion rate*	*The manufacturer for which this holds*
Parking Brakes	Latches/Locks/Linkages	Nissan
Parking Brakes	Other Air Bags	Nissan
Parking Brakes	Power Train	Nissan
Parking Brakes	Seat Belts/Child Seat Anchors	Nissan
Parking Brakes	Seat Belts/Child Seat Anchors	GM
Parking Brakes	Seats	Nissan
Parking Brakes	Structure	GM
Parking Brakes	Suspension	Nissan
Parking Brakes	Takata Air Bags	GM
Parking Brakes	Tires and Wheels	GM
Parking Brakes	Vehicle Speed Control	GM
Power Train	Equipment	Ford
Power Train	Parking Brakes	Chrysler
Power Train	Seat Belts/Child Seat Anchors	GM
Power Train	Structure	GM
Power Train	Takata Air Bags	GM
Power Train	Tires and Wheels	Ford
Power Train	Tires and Wheels	GM
Power Train	Tires and Wheels	Other mfr
Power Train	Vehicle Speed Control	GM
Seat Belts/Child Seat Anchors	Lighting	Toyota
Seats	Structure	GM
Seats	Tires and Wheels	Other mfr
Service Brakes	Lighting	Toyota
Service Brakes	Other Air Bags	Chrysler
Service Brakes	Parking Brakes	Other mfr
Service Brakes	Parking Brakes	Chrysler
Service Brakes	Seat Belts/Child Seat Anchors	Other mfr
Service Brakes	Seat Belts/Child Seat Anchors	GM
Service Brakes	Structure	GM
Service Brakes	Tires and Wheels	Other mfr
Service Brakes	Vehicle Speed Control	GM
Service Brakes	Vehicle Speed Control	Other mfr
Steering	Electrical System	Chrysler
Steering	Electrical System	Nissan
Steering	Equipment	Other mfr
Steering	Equipment	Ford
Steering	Lighting	Toyota
Steering	Other Air Bags	Hyundai
Steering	Other Air Bags	Chrysler
Steering	Other Air Bags	Nissan
Steering	Parking Brakes	Other mfr
Steering	Parking Brakes	Chrysler
Steering	Seat Belts/Child Seat Anchors	Other mfr
Steering	Seat Belts/Child Seat Anchors	Ford
Steering	Seat Belts/Child Seat Anchors	Nissan
Steering	Seats	Ford
Steering	Structure	GM
Steering	Suspension	Nissan
Steering	Tires and Wheels	Other mfr
Steering	Tires and Wheels	Ford

The component with the higher completion rate	*The component with the lower completion rate*	*The manufacturer for which this holds*
Steering	Vehicle Speed Control	Other mfr
Steering	Vehicle Speed Control	Honda
Steering	Vehicle Speed Control	GM
Steering	Vehicle Speed Control	Hyundai
Steering	Visibility	Other mfr
Structure	Equipment	Ford
Structure	Seat Belts/Child Seat Anchors	Nissan
Structure	Tires and Wheels	Ford
Structure	Tires and Wheels	Other mfr
Suspension	Electrical System	GM
Suspension	Equipment	Ford
Suspension	Fuel System	GM
Suspension	Other Air Bags	GM
Suspension	Parking Brakes	Chrysler
Suspension	Seat Belts/Child Seat Anchors	GM
Suspension	Steering	GM
Suspension	Structure	GM
Suspension	Takata Air Bags	GM
Suspension	Tires and Wheels	GM
Suspension	Tires and Wheels	Ford
Suspension	Tires and Wheels	Other mfr
Suspension	Vehicle Speed Control	GM
Suspension	Vehicle Speed Control	Honda
Suspension	Visibility	GM
Takata Air Bags	Electrical System	Other mfr
Takata Air Bags	Electrical System	Honda
Takata Air Bags	Engine & Cooling	Other mfr
Takata Air Bags	Equipment	Other mfr
Takata Air Bags	Equipment	Ford
Takata Air Bags	Equipment	Honda
Takata Air Bags	Fuel System	Honda
Takata Air Bags	Latches/Locks/Linkages	Other mfr
Takata Air Bags	Latches/Locks/Linkages	Honda
Takata Air Bags	Lighting	Other mfr
Takata Air Bags	Lighting	Honda
Takata Air Bags	Lighting	Toyota
Takata Air Bags	Other Air Bags	Other mfr
Takata Air Bags	Other Air Bags	Nissan
Takata Air Bags	Other Air Bags	Honda
Takata Air Bags	Parking Brakes	Other mfr
Takata Air Bags	Power Train	Other mfr
Takata Air Bags	Power Train	Honda
Takata Air Bags	Seat Belts/Child Seat Anchors	Other mfr
Takata Air Bags	Seat Belts/Child Seat Anchors	Ford
Takata Air Bags	Seat Belts/Child Seat Anchors	Nissan
Takata Air Bags	Seats	Other mfr
Takata Air Bags	Seats	Ford
Takata Air Bags	Seats	Honda
Takata Air Bags	Service Brakes	Other mfr
Takata Air Bags	Service Brakes	Honda
Takata Air Bags	Steering	Honda

The component with the higher completion rate	*The component with the lower completion rate*	*The manufacturer for which this holds*
Takata Air Bags	Steering	Other mfr
Takata Air Bags	Structure	Other mfr
Takata Air Bags	Structure	Honda
Takata Air Bags	Suspension	Other mfr
Takata Air Bags	Suspension	Toyota
Takata Air Bags	Tires and Wheels	Honda
Takata Air Bags	Tires and Wheels	Ford
Takata Air Bags	Tires and Wheels	Other mfr
Takata Air Bags	Vehicle Speed Control	Honda
Takata Air Bags	Vehicle Speed Control	Other mfr
Takata Air Bags	Visibility	Honda
Takata Air Bags	Visibility	Other mfr
Tires and Wheels	Lighting	Toyota
Tires and Wheels	Parking Brakes	Chrysler
Vehicle Speed Control	Lighting	Toyota